Measurement of Cross Sections for the ^{63}Cu(a,g)^{67}Ga Reaction from 6-8.8 MeV

M. S. Basunia[1], E. B. Norman[1], H. A. Shugart[2], A. R. Smith[1], M. Dolinski[2], B. J. Quiter[3]
[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*
[2] *Department of Physics, UC Berkeley, Berkeley, California 94720*
[3] *Department of Nuclear Engineering, UC Berkeley, Berkeley, California 94720*

As has been pointed out in a number of recent papers [1 and references therein], there are a number of astrophysical environments where charged-particle induced reactions on nuclei heavier than iron may play important roles. There are theoretical estimates of the cross sections for these kinds of reaction. Within the last few years, measurements have been reported for proton-induced reactions on nuclei in the region of A = 90 – 100 [2,3] and for alpha capture on ^{144}Sm and ^{70}Ge isotopes [4,5].

We have measured cross-sections for the ^{63}Cu(α,γ)^{67}Ga reaction in the 6-8.8 MeV alpha-energy range using an activation technique. Stacks of four ^{nat}Cu metal foils of 1 mg/cm^2 thickness and one ^{nat}Ti foil of thickness 2.7 mg/cm^2 were bombarded with alpha beams from the 88″ Cyclotron at LBNL. Two stacks were irradiated with alpha energies of 8.8 MeV and 7.9 MeV and a beam current of 1μA for an hour. The third stack was irradiated for 6 hours with about 0.1 μA current and a beam energy of 7.0 MeV. The titanium foil, at the end of stack, was used for checking the current integration by measuring ^{51}Cr activity and comparing with the known ^{48}Ti(α,n)^{51}Cr cross sections [6] and as a catcher of the recoil ^{67}Ga radioisotopes to estimate the recoiled fraction. Following each irradiation, the copper targets were counted immediately using an HPGe detector to measure the ^{68}Ga activity, produced through the ^{65}Cu(α,n)^{68}Ga reaction. All the copper foils were then recounted for longer periods of time to measure the ^{67}Ga activity using another HPGe detector located inside LBNL's Low Background Facility (LBF). A portion of the HPGe γ-ray spectrum collected at the LBF is shown in Fig. 1 for the characteristic γ-energies of ^{67}Ga. The ^{67}Ga radioactivity in samples bombarded at the two higher beam energies was sufficiently high for them to be counted at 25 cm and 15 cm away from the detector, however, for the lowest beam energy, samples needed to be counted at the surface of the HPGe detector. Efficiency calibration at the surface position was corrected appropriately for coincidence summing. The measured fraction of the ^{67}Ga recoiling out of the target was found to be about 10%-14%. Assuming uniform ^{67}Ga recoil out of the successive foils in the stack, a correction of 12% was made for the first target foil activity in each stack. There was an overlapping bombarding energy for the last foil of the 1st stack and the 1st foil of the 2nd stack. The agreement between ^{67}Ga activities in these two foils was excellent.

Measured cross-sections for the ^{63}Cu(α,γ)^{67}Ga reaction are compared in Fig. 2 with the theoretical values taken from the Table of NON-SMOKER cross-sections [8]. The measured values are found to be about 8%-15% lower than the theoretical values. The uncertainty of the measured cross-sections is about 15%. The comparison of measured ^{65}Cu(α,nγ)^{68}Ga cross-sections and those of Stelson *et al.* [7] is excellent. This agreement provides an indication of the experimental integrity for the ^{63}Cu(α,γ)^{67}Ga cross-sections measurement.

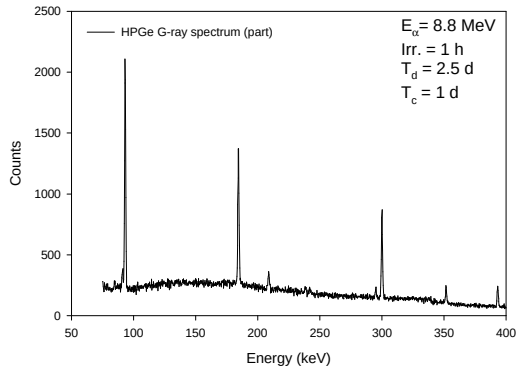

FIG. 1: Part of the HPGe γ-ray spectrum showing ^{67}Ga characteristic γ lines.

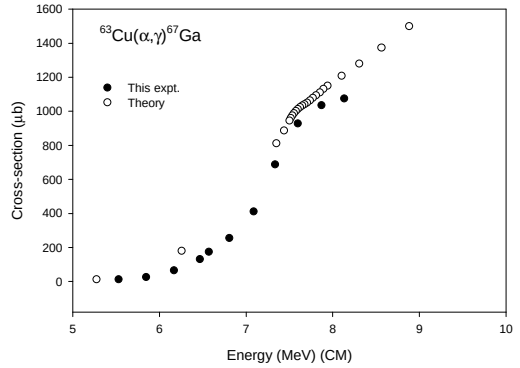

FIG. 2: Experimental and theoretical cross-sections for the ^{63}Cu(α,γ)^{67}Ga reaction.

REFERENCES

[1] R. D. Hoffman, S. E. Woosley, and Y.-Z. Qian, Astrophys. J. 482, 951 (1997).
[2] T. Sauter and F. Kappeler, Phys. Rev. C 55 (1997) 3127.
[3] J. Bork, H. Schatz, F. Kappeler, and T. Rauscher, Phys. Rev. C 58 (1998) 524.
[4] E. Somorjai, Zs. Fülöp, Á.Z. Kiss, C. Rolfs, H-P. Trautvetter, U. Greife, M. Junker, M. Arnould, M. Rayet, and H. Oberhummer, Nucl. Phys. A 621, 293c (1997).
[5] Zs. Fülöp, Á.Z. Kiss, E. Somorjai, C.E. Rolfs, H.P. Trautvetter, T. Rauscher, H. Oberhummer, Z. Phys. A 355, 203 (1996).
[6] A. J. Morton, S.G. Tims, A.F. Scott, V.Y. Hansper, C.I.W. Tingwell, and D.G. Sargood, Nucl. Phys. A 537, 167 (1992).
[7] P.H. Stelson and F.K. McGowan, Phys. Rev. 133, B911 (1964).
[8] T. Rauscher ,(http://quasar.physik.unibas.ch/cgi-bin/query)